

FOLSOM DAM
BORROW SITE ANALYSIS

AMERICAN RIVER WATERSHED LONG TERM STUDY

FOLSOM DAM BORROW INVESTIGATIONS



Photo Courtesy of Pattermann Aviation - May 2000

SEPTEMBER 2001

**U. S. ARMY CORPS OF ENGINEERS
SOIL DESIGN SECTION - GEOTECHNICAL BRANCH
SACRAMENTO DISTRICT - SOUTH PACIFIC DIVISION**

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1.0 Introduction.

Borrow site investigations are a complicated and difficult task for a dam, especially when located in an urban area. After the construction of the original dam (1956) and especially after the modifications to Mormon Island Dam, those that have worked in the area have stated that "borrow is not available." The following report presents the findings and actions taken to date.

2.0 Potential Borrow Sites.

Many different sites have been suggested and a number have been researched. Table 2.1 presents a list of potential sites and the current status.

Table 2.1 Potential Borrow Sites.

Name	Status
Aerojet Property	Rejected - Superfund Site
Auburn Cofferdam Runoff	Rejected - Difficult and Costly to Locate, Excavate, and Haul
Within Reservoir	Requires Further Investigation
Peninsula	Investigated – This Report
Mississippi Bar	Investigated – This Report
Old Borrow Site #4	Rejected – Archaeology
Other Sites	To be investigated as Project continues

a. Aerojet.

Personnel were contacted in the real estate division by the Soil Design Section for the Aerojet facility located at Highway 50 & Aerojet Road, Rancho Cordova, California. The personnel stated that material may be available but that the site is currently under superfund status investigation for the contamination of soils. This site was dropped from further consideration. Contact was Mr. Terri Griffin at the Aerojet Real Estate Office, (916) 351-8584.

b. Within Reservoir.

Use of material within the existing reservoir may be possible, but these areas were used during the construction of the original dam and it is expected that they most likely would be depleted. Also, the extent of borrow in the shallower water areas is limited to the fact that it is not desirable to use borrow near the waterside toes of the embankments and dikes, as this may increase the likelihood of underseepage. It is desirable not to extract borrow from no closer than 500 feet from the waterside toes of the embankment, these limits are shown in Figures 2.1 and 2.2, along with a plot of historical Folsom reservoir elevations in Figure 2.3. The Folsom reservoir elevations shown in Figure 2.3 are for the purpose of demonstrating the small amount of available planform area when considering the restrictions on borrow limits at the embankment toes (500 feet) and normal reservoir operations. It can be seen that very little surface area is

available given the current constraints. Material may be extracted above 400' elevation during dry years and above 425' elevation during wet years.

c. Auburn Cofferdam Runoff.

It was suggested that Auburn cofferdam runoff material could be used as a borrow source. This was researched and considered to be an option of "last resort" since transporting operations would be difficult and costly. This site was dropped from further consideration.

d. Peninsula.

The peninsula between the North and South Forks of the American River of the Folsom Reservoir is considered a viable option. A field reconnaissance was conducted of the site in May 2000. Several clear areas were observed and an investigation plan was developed in June 2000 and rights-of-entry initiated at that time. It appears from visual observations that the area would contain an upper 4 to 6 foot layer of fine-grained material and below that unknown depths of weathered rock. A plan to conduct backhoe investigations would reveal the extent of the upper fine-grained material and the degree of weathering of the rock. One distinct advantage of this site is that material can be barged to the dams and dikes instead of transported by heavy vehicles.

e. Mississippi Bar.

Initial explorations were mapped out in June 2000. Field reconnaissance of the site was conducted in July 2000. Also, a mineral report was received from the Bureau of Reclamation (contact: Gale Moginie) in August 2000, entitled "Mineral Appraisal for a Competitive Lease of Sand and Gravel and Placer Gold at Mississippi Bar, near Folsom, Sacramento County, California." The report was prepared by the Bureau of Land Management, Division of Mineral Resources, Branch of Mining Law and Soil Minerals, dated July 31, 1987, and provided a source of preliminary information.

In order to investigate the site, a large amount of coordination had to be conducted between the Bureau of Rec., State Parks, Fish & Wildlife, etc. Mississippi Bar located just upstream and northeast of Nimbus Dam was investigated on 03 May 2001.

f. Old Borrow Site #4.

Old borrow site #4 located in Granite Bay in the area of Dike #1 is a site that was originally investigated for the original Folsom Dam construction and it appears that it may not have been fully utilized.

Site was rejected to due archaeological restrictions.

3.0 Borrow Site Investigations.

Backhoe trench explorations were conducted for the Mississippi Bar and Peninsula sites. These two sites went through a 10 month process of obtaining the required approvals for environmental, state parks, etc., until permission was received to proceed with the explorations. The investigations were finally

conducted during the first week of May 2001 and took approximately 3 days to complete.

4.0 Results of Field Investigations.

The results of the field investigations are described for each site, Mississippi Bar and Peninsula, in the following subsections. The soil descriptions correspond to the standards set forth in ASTM D2488, "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)."

a. Mississippi Bar.

A total of 9 trenches were conducted by backhoe up to maximum depths of 12 feet. The locations of the trenches can be seen in Figure 4.1. The Mississippi Bar trenches are numbered 4B-01-1MB through 4B-01-9MB. The trenches were strategically located so that approximately half would be conducted in the above ground surface mounds of dredge tailings and about half would be conducted in the "level" ground surface below the mounds of dredge tailings.

As expected, a large amount of the material encountered during the explorations consisted of cobbles. But the purpose of the below ground surface explorations was to investigate the anticipated large amount of sands and fines located within the samples which would produce a better fill material. Those trenches conducted above the ground surface in the dredge tailings mounds include trenches 4B-01-2MB, 4MB, 6MB-8MB. Those conducted below the "level" ground surface include trenches 4B-01-1MB, 3MB, 5MB, 9MB.

The distribution of materials for the explorations conducted in the dredge tailings mounds and those conducted below the "level" ground surface are shown in Table 4.1. Weighted averages, percentages versus depths, were used for all calculations. The average depth for the trenches excavated in the mounds is equal to 8.6 feet. The average depth for the trenches excavated below the "level" ground surface is equal to 9.25 feet. ASTM D2488 requires that cobbles be reported as a percentage of the total sample. Gravels, sands, and fines are reported as a percentage of 100% of the material passing the 3-inch sieve.

Table 4.1. Weighted Average Distribution of Materials for Mississippi Bar - Visual Examinations

Location	Percentage of Materials				ASTM D2488 Description
	3" to 12"	Passing (minus) 3"			
	Cobbles	Gravels	Sands	Fines	
Dredge Tailings Mounds	40	60	35	5	Well Graded Gravel with Sand and Cobbles
Below "level" Ground Surface	10	25	65	10	Poorly Graded Sand with Silt and Gravel and Cobbles

b. Peninsula.

A total of 9 trenches were conducted by backhoe up to maximum depths of 11 feet. The locations of the trenches can be seen in Figure 4.2. The peninsula trenches are numbered 4B-01-1P through 4B-01-9P. The trench explorations were not only necessary to identify materials but were also necessary to locate the depths at which sound rock was encountered. The trenches were excavated with a rubber-tired CASE 580E backhoe with a 2' wide bucket. No extraordinary measures were taken to excavate the rock-like materials so that a good indication is given as to the relative ease of excavation for the actual depths shown.

The distribution of materials for the Peninsula explorations are shown in Table 4.2. Weighted averages, percentages versus depths, were used for all calculations. The average excavation depth of the peninsula trenches is equal to 7.89 feet. Essentially, the top 3 feet of the explorations are clayey and silty sand sediments and the materials below 3 feet are highly to totally weathered granite. It is expected that the highly to totally weathered granite material will further breakdown as placement procedures are executed. Excavating, hauling, and primarily compaction will increase the amounts of finer material. Test fills should be conducted varying the size of compaction equipment and the number of passes prior to the construction of the dam.

Table 4.2 Weighted Average Distribution of Materials for Peninsula – Visual Examinations

Location	Percent Passing 3" Sieve			ASTM D2488 Description
	Gravels	Sands	Fines	
Top 3 feet	0	80	20	Clayey Sand
Below 3 feet	5	85	10 ^a	Totally to highly weathered granite - Poorly Graded Sand with Silt and/or Clay

^a Fines content expected to increase substantially as material is placed and compacted. Test fills should be conducted.

5.0 Results of Laboratory Testing.

To be completed.

6.0 Site Stratigraphy and Geotechnical Properties.

To be completed.

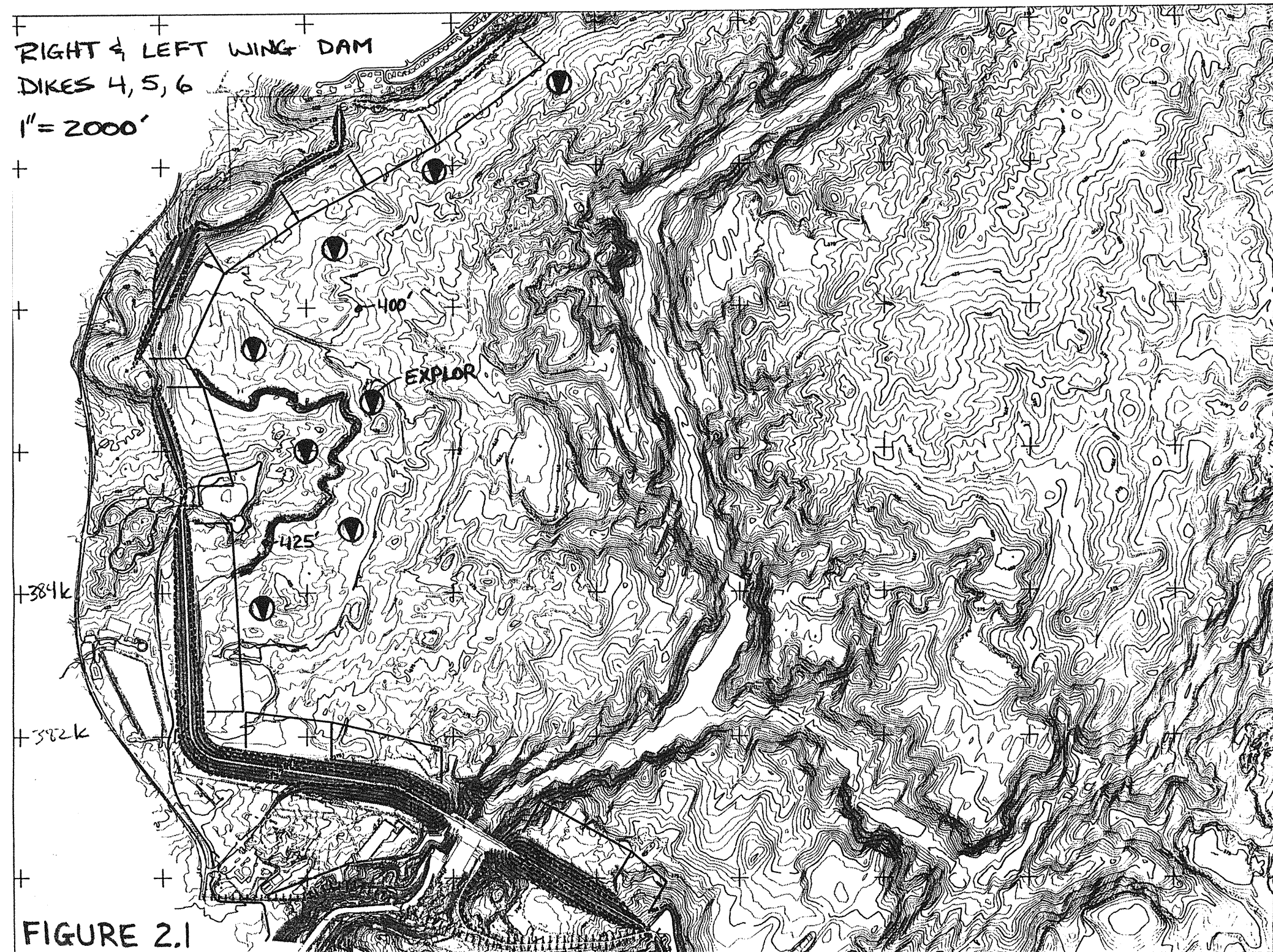
7.0 Other Sites Investigated by SAFCA

To be completed.

8.0 Conclusions.

Field investigations are currently based on visual classifications and need to be verified and further defined with laboratory results. Test fills should be conducted of the highly to totally weathered granite material to determine degree of particle breakdown.

To be completed.



Folsom Daily Reservoir Elevations

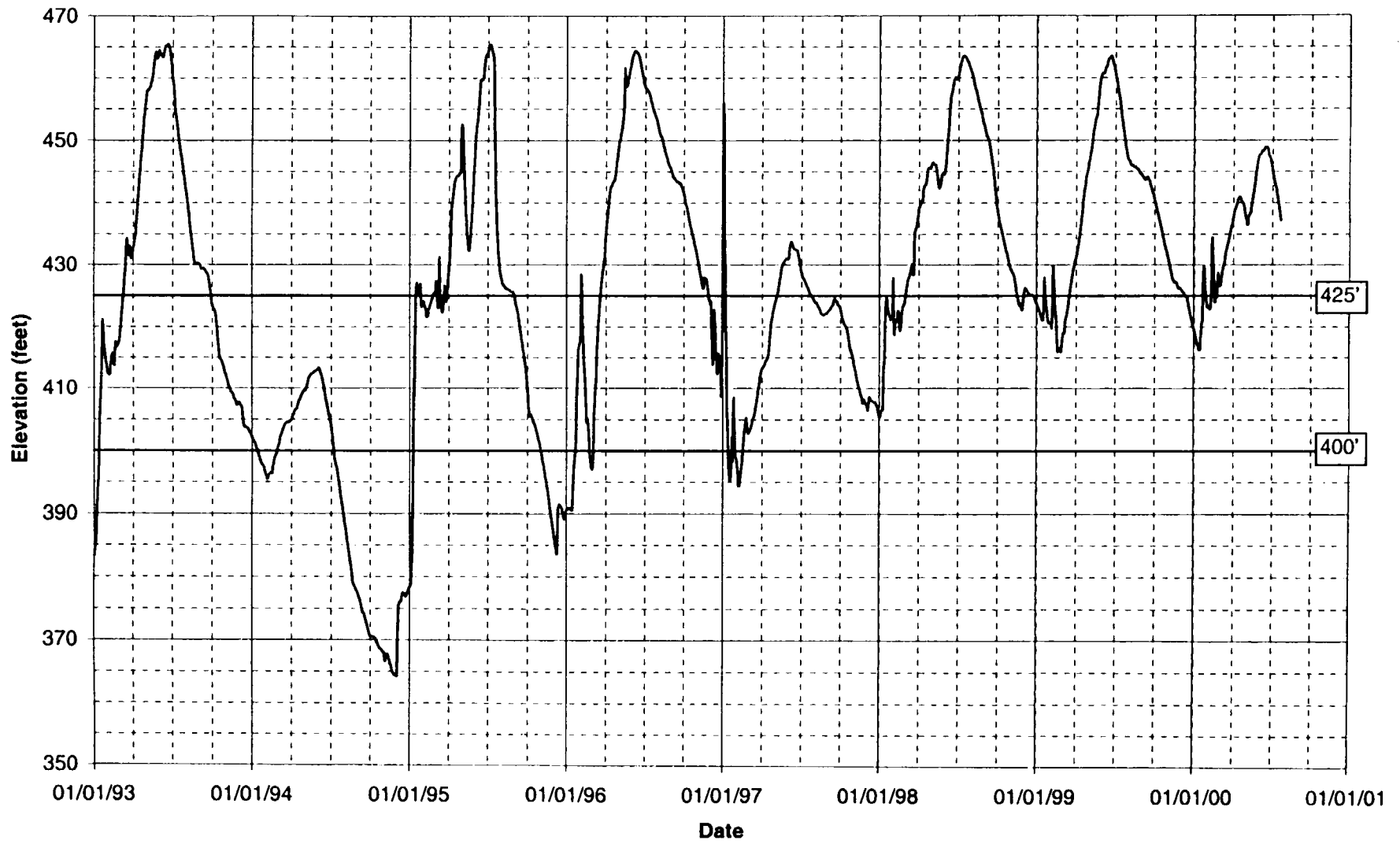
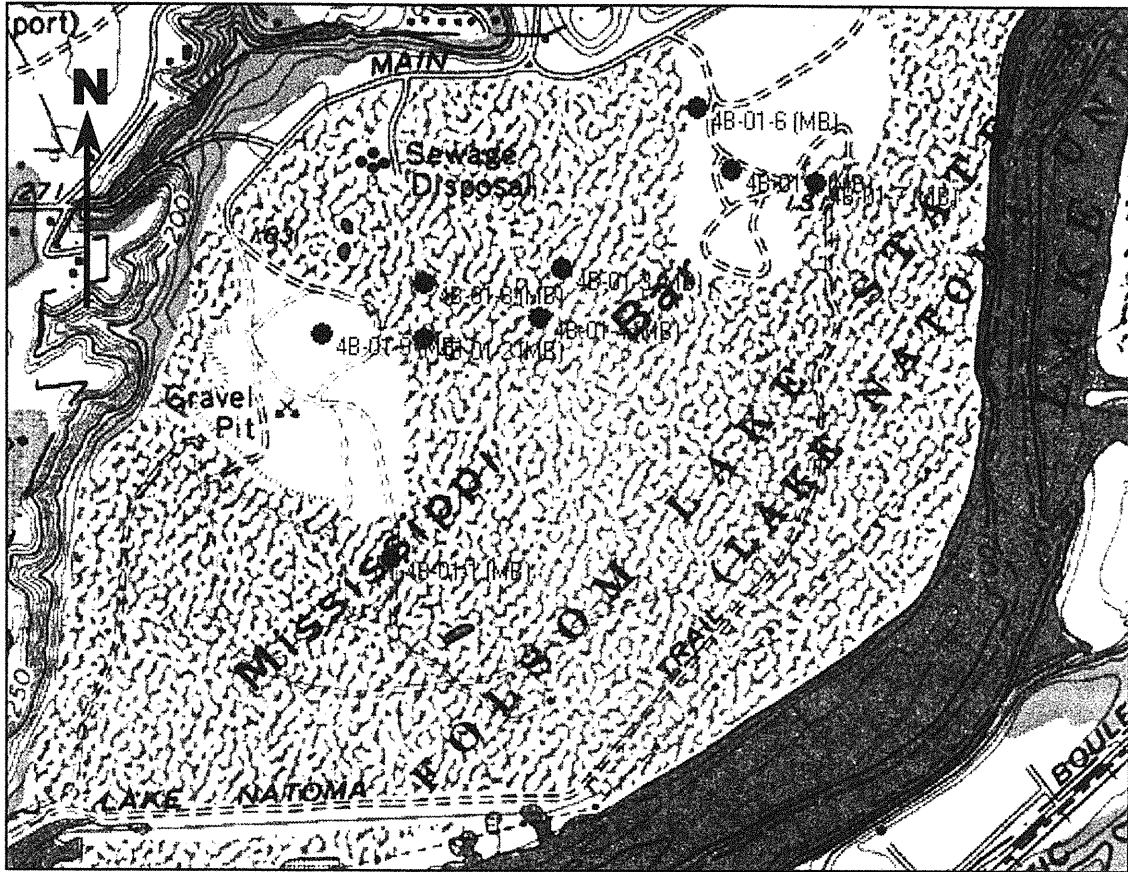


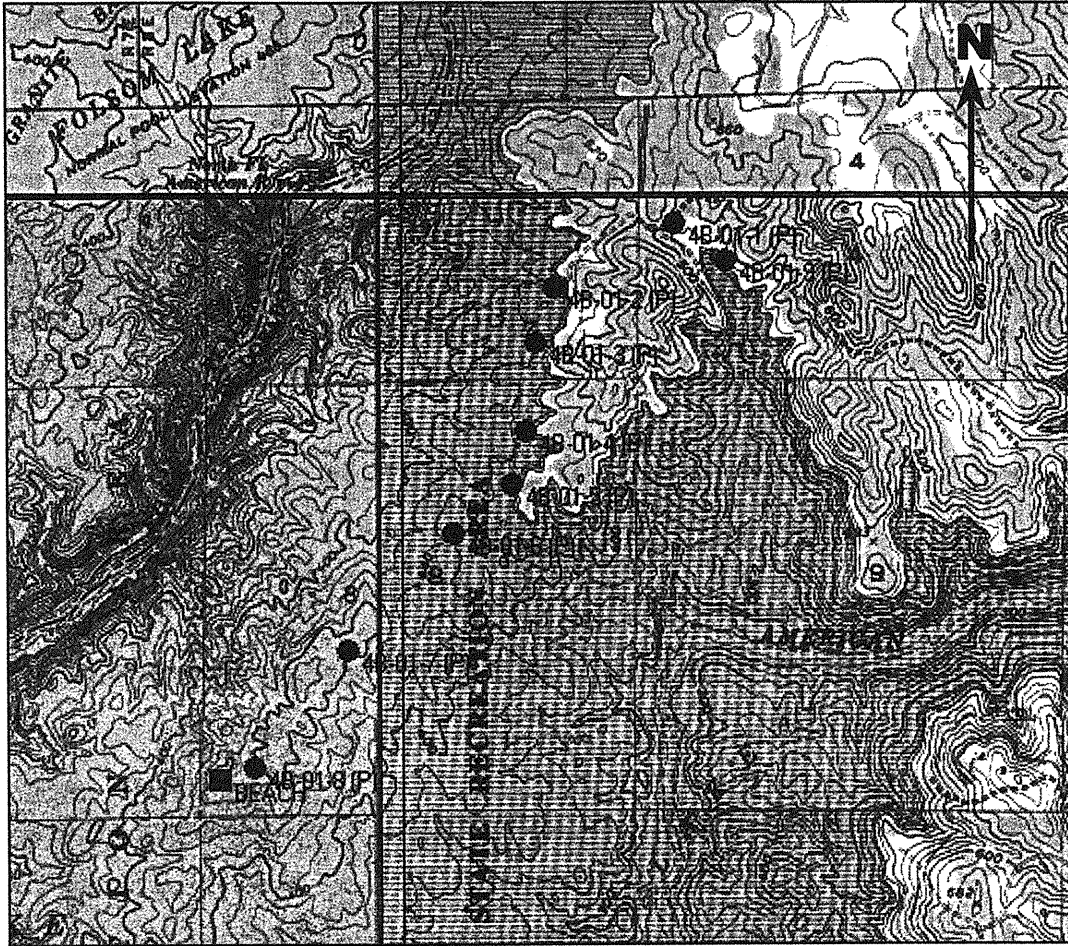
FIGURE 2.3



[Lake Natoma Pool Elevation at Time of Explorations (5/01) ~ 123.00 feet]
(USGS QUAD: Folsom)

Trench Number	UTM (NAD83)	
	E	N
4B-01-1MB	10 06 56039	42 79183
4B-01-2MB	10 06 56091	42 79598
4B-01-3MB	10 06 56349	42 79730
4B-01-4MB	10 06 56306	42 79638
4B-01-5MB	10 06 56659	42 79923
4B-01-6MB	10 06 56592	42 80035
4B-01-7MB	10 06 56818	42 79901
4B-01-8MB	10 06 55900	42 79600
4B-01-9MB	10 06 56087	42 79700

Figure 4.1. Location Of Mississippi Bar Borrow Site Exploration Trenches

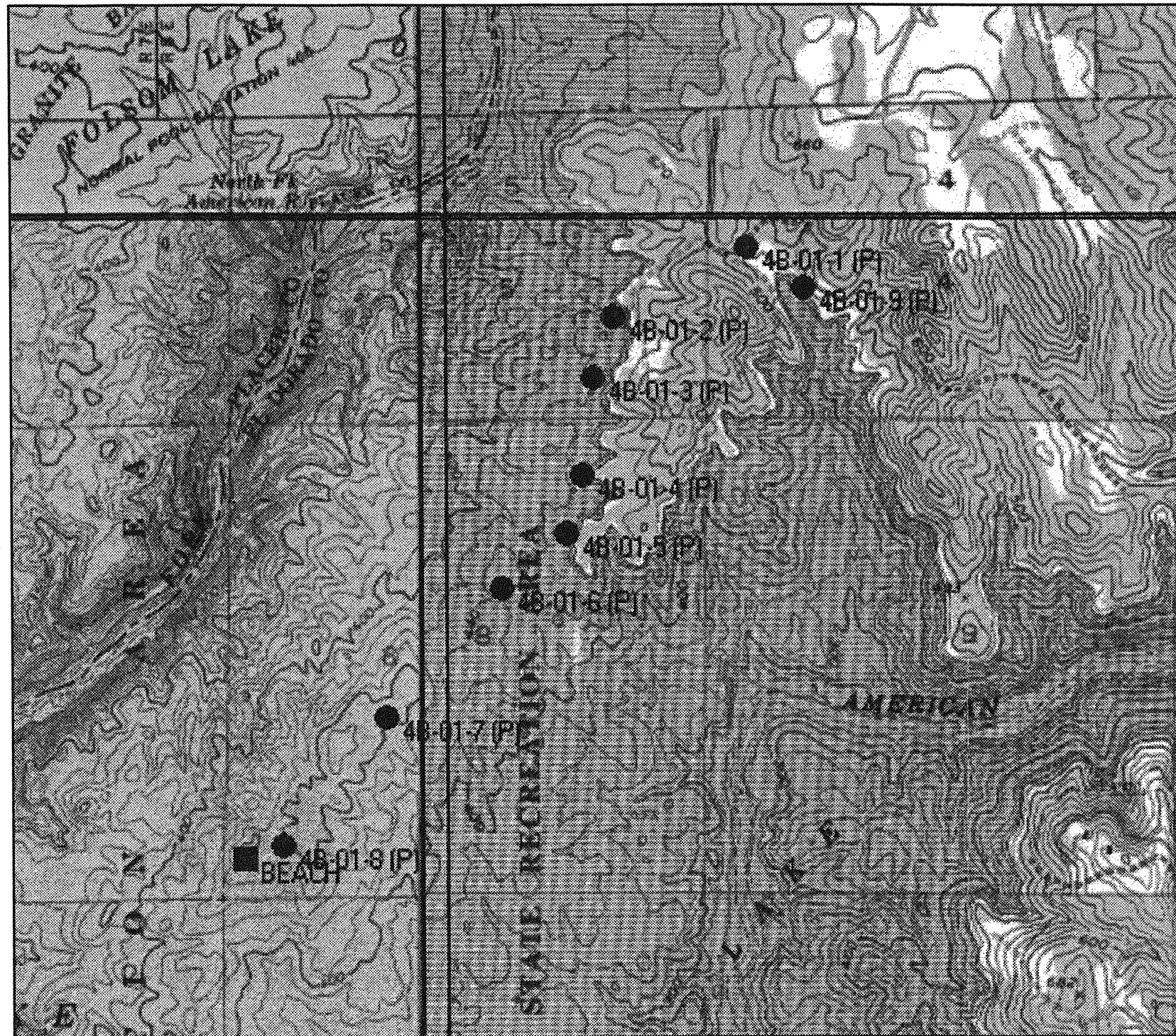


[Folsom Lake Pool Elevation at Time of Explorations (5/01) ~ 435.00 feet]
 [USGS QUADS: Folsom (SW), Rocklin (NW), Pilot Hill (NE), Clarksville (SE)]

Trench Number	UTM (NAD83)	
	E	N
4B-01-1P	10 06 63965	42 90610
4B-01-2P	10 06 63519	42 90367
4B-01-3P	10 06 63450	42 90154
4B-01-4P	10 06 63414	42 89827
4B-01-5P	10 06 63367	42 89619
4B-01-6P	10 06 63154	42 89431
4B-01-7P	10 06 62760	42 88986
4B-01-8P	10 06 62423	42 88539
4B-01-9P	10 06 64161	42 90473
BEACH	10 06 62290	42 88495

Figure 4.2 Location of Peninsula Borrow Site Exploration Trenches

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NOT TO SCALE

LEGEND :

GR	Gravel, Percent by Weight Passing the 3" Sieve and Retained on the No. 4 Sieve.
SA	Sand, Percent by Weight Passing the No. 4 Sieve and Retained on the No. 200 Sieve.
FI	Fines, Percent by Weight Passing the No. 200 Sieve.
LL	Liquid Limit.
PI	Plasticity Index.
MC	Laboratory Determined Moisture Content in Percent of Dry Weight.
γ_d	Dry Density.
G_s	Specific Gravity.
SM	Combined Field Visual Identification and/or Laboratory Classification.
NP	Nonplastic.
∇	Water Level.
B.O.T.	Bottom of Trench.

NOTES :

1. This drawing is to be used only for approximate location of explorations and description of subsurface conditions.
2. Soil classifications and descriptions are based on field log descriptions in accordance with ASTM D 2488 ("Description and Identifications of Soils, Visual-Manual Procedure") and/or laboratory test results in accordance with ASTM 2487 ("Classification of Soils for Engineering Purposes").
3. All colors shown are in accordance with the "Munsell Soil Color Chart".
4. All sieve sizes shown are U.S. Standard.
5. Trenches 4B-01-1(P) through 4B-01-9(P) were excavated with a rubber-tired CASE 580E backhoe using a 2-foot wide bucket on 3 May 2001.
6. Groundwater was encountered at the time of explorations. Groundwater levels can be expected to fluctuate in response to rainfall variations, particularly in the vicinity of site drainage features.
7. Depending on the soil moisture at the time of construction, the soil encountered may be unstable or potentially unstable. The probability of unstable conditions is highest when the soil moisture is greatest.
8. Cobbles (+3-inch sieve) were scalped in the field and were not included in laboratory testing.
9. Logs of Explorations are shown on Sheet Nos. B-2 and B-3.
10. Coordinates shown are in UTM feet, NAD 83.

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Rev.	Date	Design file no.	Spec No.	Drawing Code	Project No.	Sheet No.	Scale	Author	Checker	Engineer	Approved

Designed by: K. Pottmann	Drawn by: R. Teller	Reviewed by: K. Pottmann	Submitted by: K. Pottmann	Project No. 22-40-001	Sheet No. 111
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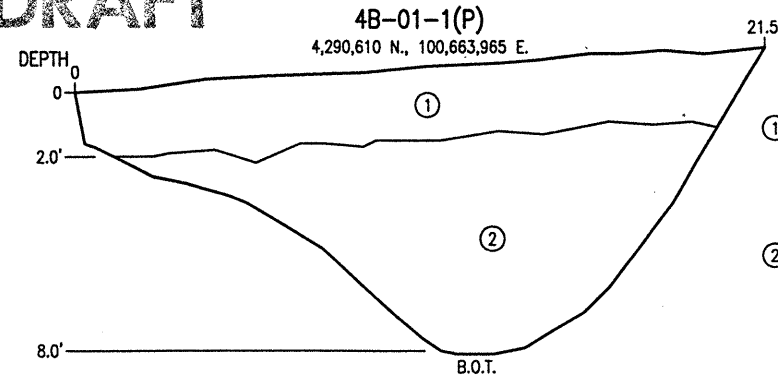
CALIFORNIA

AMERICAN RIVER PROJECT
LONG TERM STUDY

LOCATION OF EXPLORATIONS
4B-01-1P THROUGH 4B-01-9P

Sheet
reference
number:
B-1

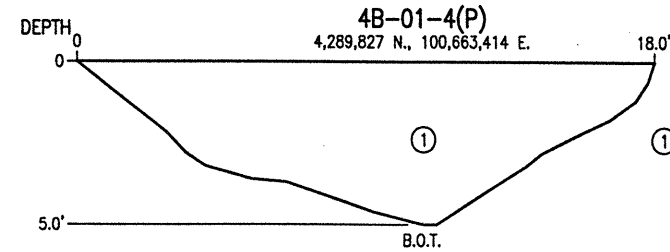
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① CLAYEY SAND, SC: Moist; dark grayish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 20% low to medium plasticity, low to medium toughness, slow dilatancy fines

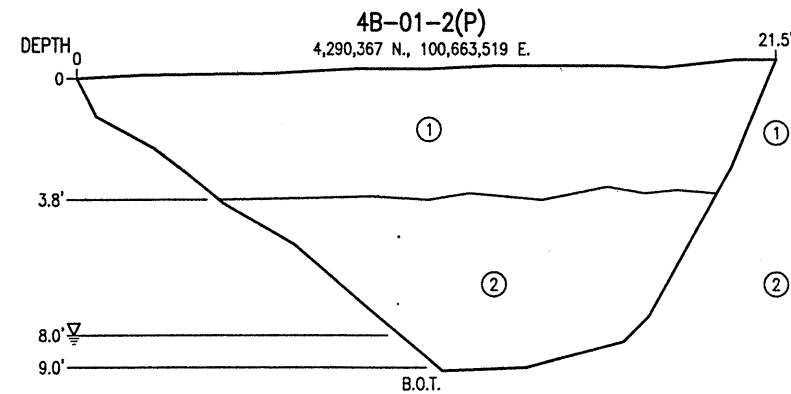
② HIGHLY TO COMPLETELY WEATHERED ROCK, GRANITE: When excavated becomes POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Moist; yellowish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 10% fine to coarse, hard, subrounded gravel to 3" maximum size; 10% nonplastic fines

GR	SA	FI	LL	PI	MC



① POORLY GRADED SAND WITH CLAY, SP-SC: Moist; yellowish-brown; 90% fine to coarse, hard, subrounded to subangular sand; 10% medium plastic fines

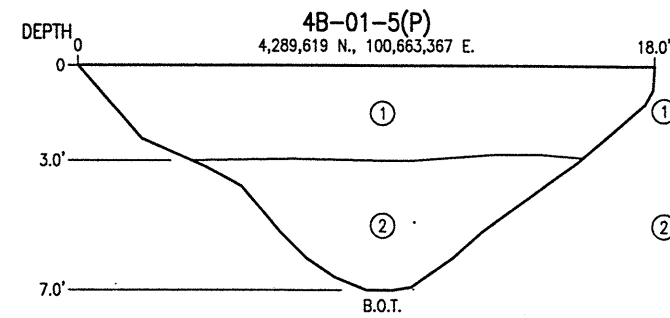
GR	SA	FI	LL	PI	MC



① COMPLETELY WEATHERED ROCK, GRANITE: When excavated becomes POORLY GRADED SAND WITH CLAY, SP-SC: Moist; dark grayish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 10% low to medium plasticity fines; 10% fine to coarse, hard, subangular gravel to 3" maximum size

② HIGHLY TO COMPLETELY WEATHERED ROCK, GRANITE: When excavated becomes POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Moist; yellowish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 10% fine to coarse, hard, subrounded gravel to 3" maximum size; 10% nonplastic fines
Below 8.5' depth, difficult to excavate

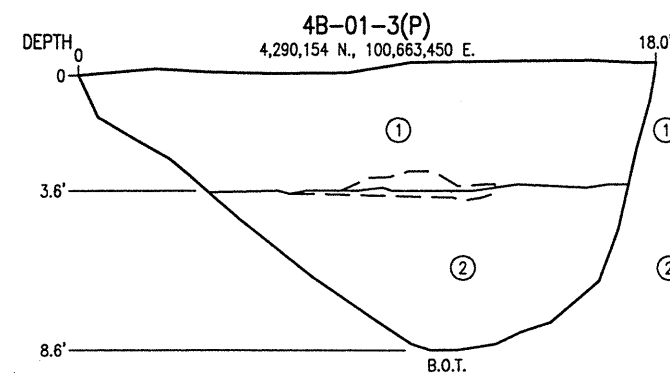
GR	SA	FI	LL	PI	MC



① CLAYEY SAND, SC: Wet; dark grayish-brown; 85% fine to coarse, hard, subrounded to subangular sand; 15% low to medium plasticity fines

② COMPLETELY WEATHERED ROCK, GRANITE: When excavated becomes POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Moist; yellowish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 10% fine to coarse, hard, subrounded gravel to 3" maximum size; 10% nonplastic fines

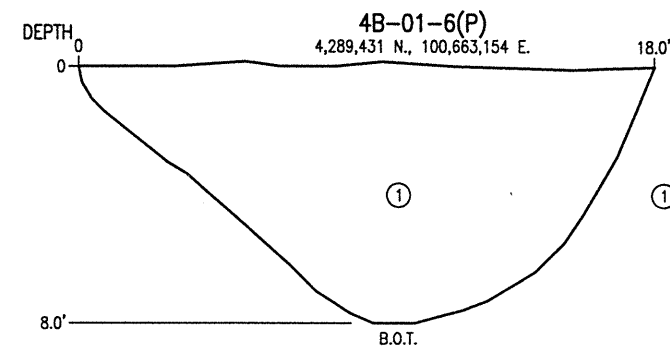
GR	SA	FI	LL	PI	MC



① CLAYEY SAND, SC: Wet; dark grayish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 20% low to medium plasticity, low to medium toughness fines

② HIGHLY TO COMPLETELY WEATHERED ROCK, GRANITE: When excavated becomes POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Moist; yellowish-brown; 80% fine to coarse, hard, subrounded to subangular sand; 10% fine to coarse, hard, subrounded gravel to 3" maximum size; 10% nonplastic fines

GR	SA	FI	LL	PI	MC



① HIGHLY TO COMPLETELY WEATHERED ROCK, GRANITE: When excavated becomes POORLY GRADED SAND WITH CLAY, SP-SC: Moist; brown; 90% fine to coarse, hard, subrounded to subangular sand; 10% low plasticity fines

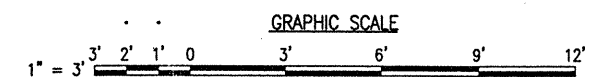
Below 8.5' depth, difficult to excavate

GR	SA	FI	LL	PI	MC

Scale: 1" = 3'

NOTES:

- Legend, notes, and location of explorations are shown on sheet no. B-1.
- Logs of explorations are shown on sheet nos. B-2 and B-3.



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Rev.	Date	Design	Drawn	Check	Appr'd	Description

Rev.	Date	Design	Drawn	Check	Appr'd	Description

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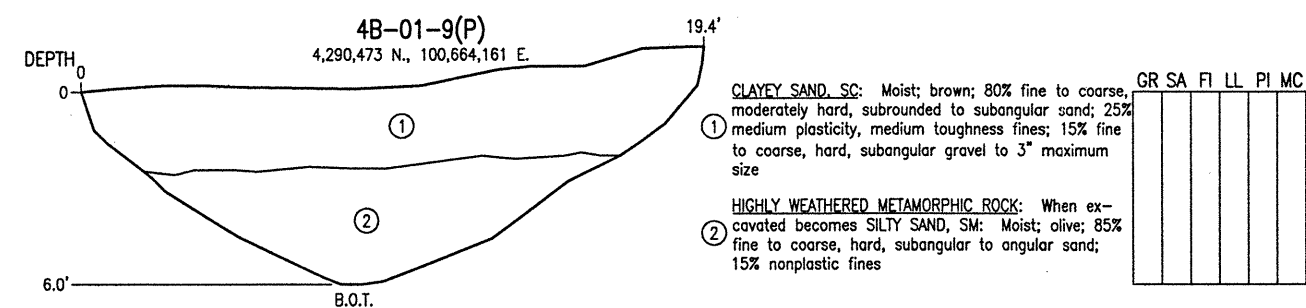
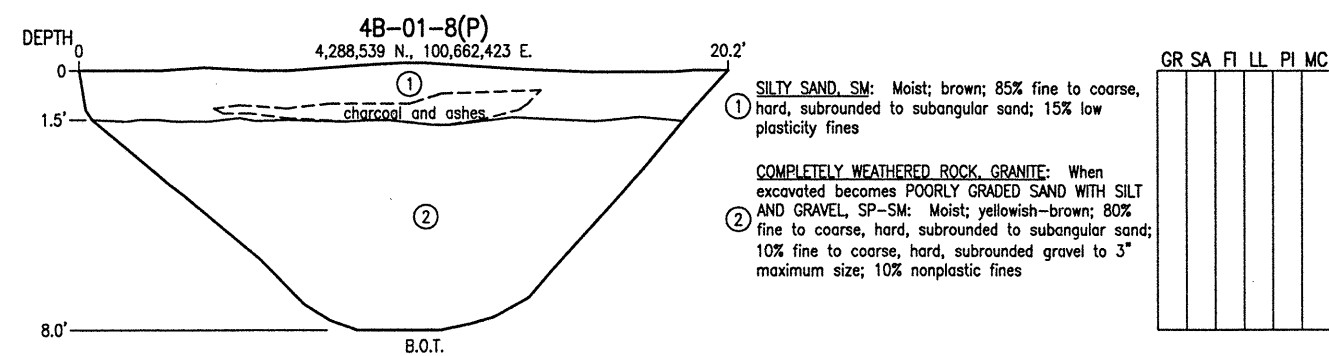
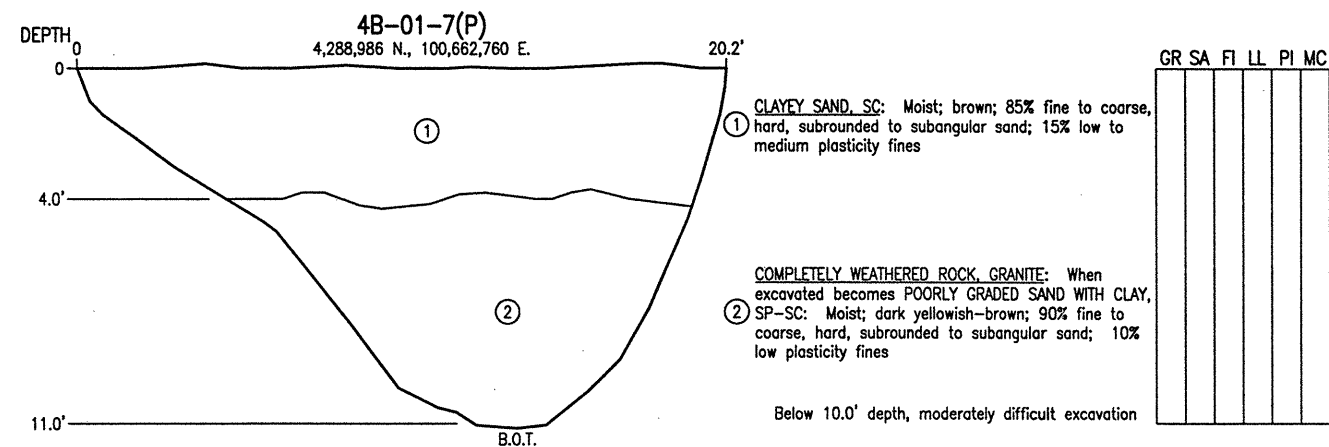
CALIFORNIA

AMERICAN RIVER PROJECT
LONG TERM STUDY

LOG OF EXPLORATIONS
4B-01-1(P) THROUGH 4B-01-6(P)

Sheet
reference
number:
B-2

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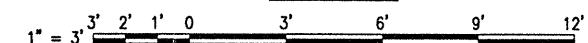
Scale: 1" = 3'

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2. Logs of explorations are shown on sheet nos. B-2 and B-3.

GRAPHIC SCALE



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K. Pattermann	Spec No.:	Design file no:	8-3.dwg 22 Jun 2001 Plot scale: 1:1
	Drawn by: R. Teiferson	Drawing Code:	
K. Pattermann	Revised by:		
	Submitted by:		
Accts. Chief, Self Design Section			

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AMERICAN RIVER PROJECT
LONG TERM STUDY

LOG OF EXPLORATIONS
4B-01-7(P), 4B-01-8(P) AND 4B-01-9(P)

Sheet
reference
number:
B-3

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NOT TO SCALE

LEGEND:

GR	Gravel, Percent by Weight Passing the 3" Sieve and Retained on the No. 4 Sieve.
SA	Sand, Percent by Weight Passing the No. 4 Sieve and Retained on the No. 200 Sieve.
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PI	Plasticity Index.
MC	Laboratory Determined Moisture Content in Percent of Dry Weight.
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∇	Water Level.
B.O.T.	Bottom of Trench.

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8. Cobbles (+3-inch sieve) were scalped in the field and were not included in laboratory testing.
9. Logs of Explorations are shown on Sheet Nos. B-5 and B-6.
10. Coordinates shown are in UTM feet, NAD 83.

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K. Pattermann	Spec No.:	Design file no:	File name: MasterB4.dwg Plot date: 22 Jun 2001 Plot scale: 1:1
	Drawn by: R. Teller	Drawing Code:	
K. Pattermann	Reviewed by:		
	Submitted by:		
Actg. Chief, Soil Design Section			

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AMERICAN RIVER PROJECT
LONG TERM STUDY

AMERICAN RIVER PROJECT
LONG TERM STUDY

LOCATION OF EXPLORATIONS

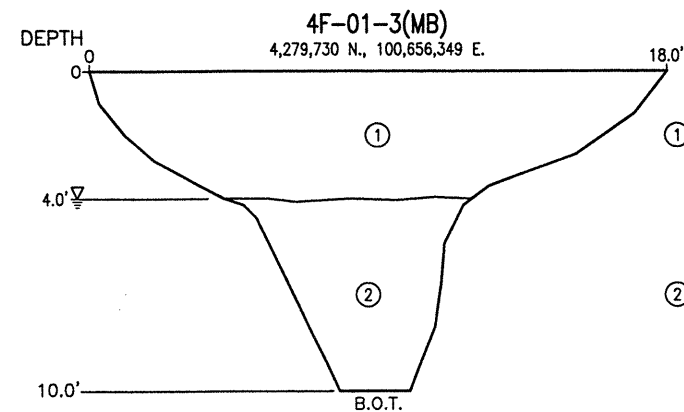
4B-01-1MB, THROUGH 4B-01-9MB

Sheet
reference
number:

3-4

① POORLY GRADED SAND WITH SILT, SP-SM: Moist; dark brown; 80% fine to coarse, hard, subrounded to subangular sand; 10% nonplastic fines; 10% fine to coarse, hard, subrounded gravel to 3" maximum size; original sample had 15% (by volume) cobbles to 8" size

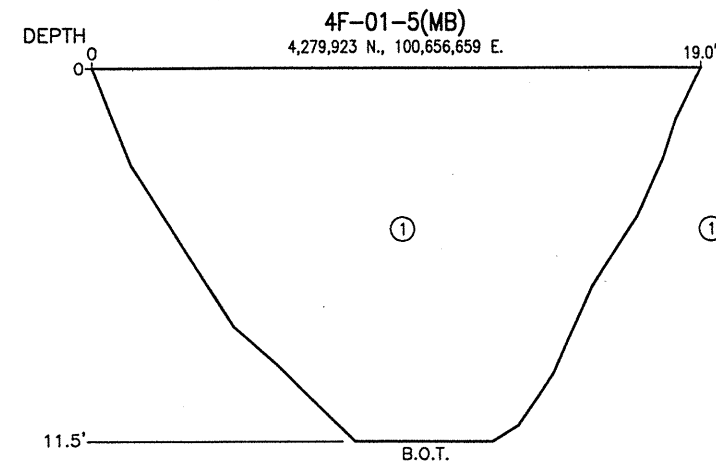
GR	SA	FI	LL	PI	MO



① WELL GRADED GRAVEL WITH SAND, GW: Moist; brown;
70% fine to coarse, hard, subrounded gravel to 3"
maximum size; 25% fine to coarse, hard, subrounded
to subangular sand; 5% fines; original sample had
30% (by volume) cobbles to 10" size

② POORLY GRADED SAND WITH SILT, SP-SM: Wet; brown; 50% fine to coarse, hard, subrounded to subangular sand; 40% fine to coarse, hard, sub-rounded gravel to 3" maximum size; 10% low plastic fines; original sample had 20% (by volume) cobbles to 8" size

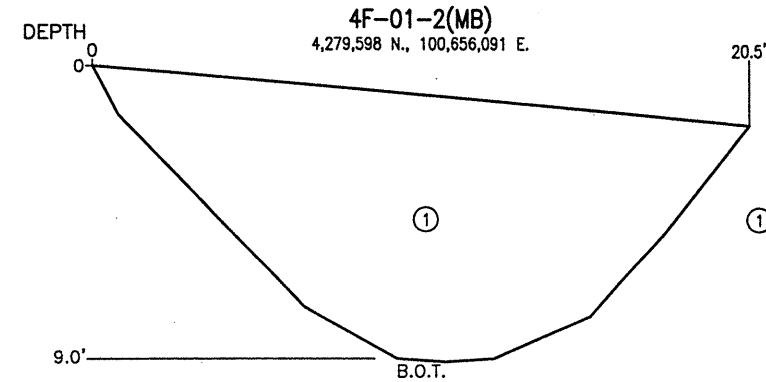
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d						
s						



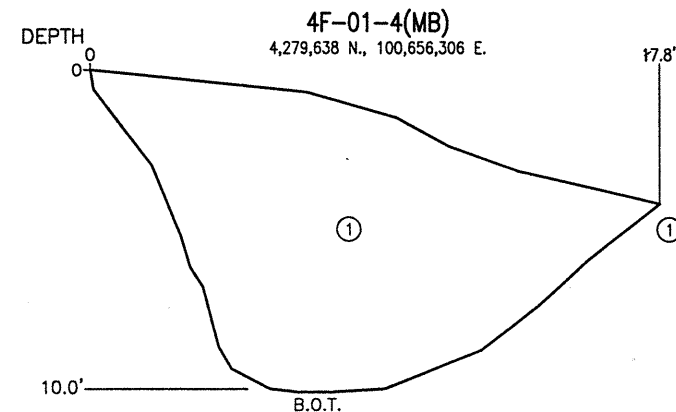
① POORLY GRADED SAND WITH GRAVEL, SP: Moist; brown; 90% fine to coarse, hard, subrounded to subangular sand; 5% fine to coarse, hard, subrounded gravel to 3" maximum size; 5% fines; original sample had 5% (by volume) cobbles to 8" size

[illegible]

Scale: 1" = 3'

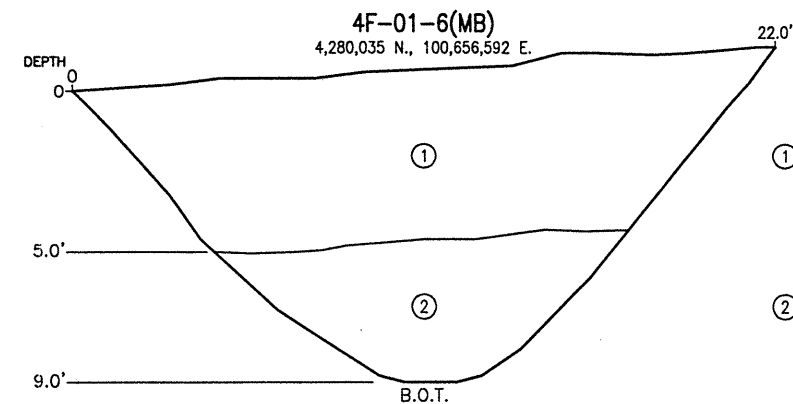


① WELL GRADED GRAVEL WITH SAND, GW: Moist, wet at bottom; brown; 35% fine to coarse, hard, sub-rounded gravel to 3" maximum size; 30% fine to coarse, hard, subrounded to subangular sand; 5% fines; original sample had 60% (by volume) cobbles to 11" size

[illegible]

① POORLY GRADED SAND WITH GRAVEL, SP: Moist; brown; 60% fine to coarse, hard, subrounded to subangular sand; 35% fine to coarse, hard, subrounded gravel to 3" maximum size; 5% fines; original sample had 25% (by volume) cobbles to 10" size

GR	SA	FI	LL	PI	MC



① WELL GRADED GRAVEL WITH SAND, GW: Moist; brown;
70% fine to coarse, hard, subrounded gravel to 3"
maximum size; 25% fine to coarse, hard, subrounded
to subangular sand; 5% fines; original sample had
45% (by volume) cobbles to 10" size

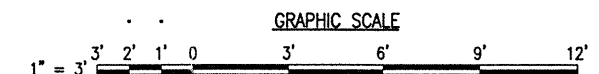
② CLAYEY GRAVEL WITH SAND, GC: Moist; dark brown; 70% fine to coarse, hard, subrounded gravel to 3" maximum size; 15% fine to coarse, hard, subrounded to subangular sand; 15% medium to high plasticity fines

	GR	SA	FI	LL	PI	MC
d						
d						

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NOTES:

1. Legend, notes, and location of explorations are shown on sheet no. B-4.
2. Logs of Explorations are shown on Sheet Nos. B-5 and B-6.



Army Corps
Engineers
Sacramento District

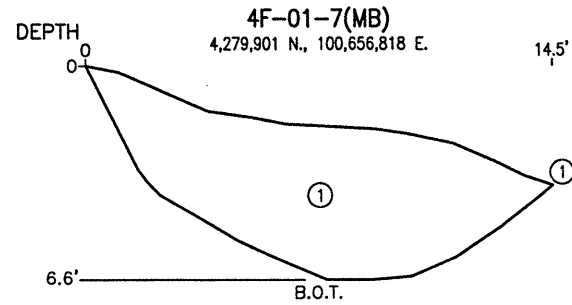
LONG TERM STUDY

LOG OF EXPLORATIONS

4B-01-1(MB) THROUGH 4B-01-6(MB)

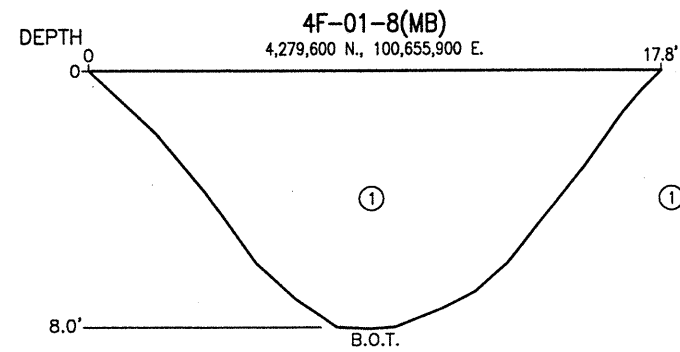
Sheet
reference
number:
B-5

DRAFT



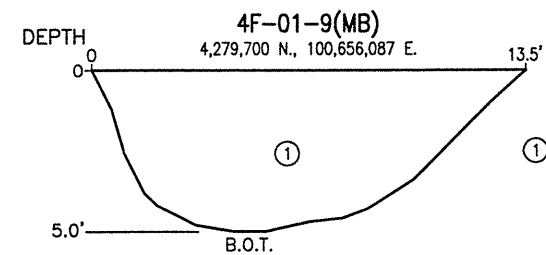
WELL GRADED GRAVEL WITH SILT AND SAND, GW-GM:
Moist; yellowish-brown; 60% fine to coarse, hard,
subrounded gravel to 3" maximum size; 30% fine to
coarse, hard, subrounded to subangular sand; 10%
low plasticity fines; original sample had 30% (by
volume) cobbles to 11" size

GR	SA	FI	LL	PI	MC



WELL GRADED GRAVEL WITH SAND, GW: Moist; brown;
65% fine to coarse, hard, subrounded gravel to 3"
maximum size; 30% fine to coarse, hard, subround-
ed to subangular sand; 5% fines; original sample had
60% (by volume) cobbles and boulders to 20" size

GR	SA	FI	LL	PI	MC



WELL GRADED GRAVEL WITH SILT AND SAND, GW-GM:
Moist; brown; 50% fine to coarse, hard, subrounded
gravel to 3" maximum size; 40% fine to coarse,
hard, subrounded to subangular sand; 10% low
plasticity fines; strong cementation (lime?)

GR	SA	FI	LL	PI	MC

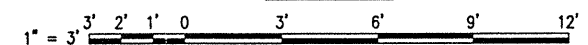
Scale: 1" = 3'

DRAFT

NOTES:

- Legend, notes, and location of explorations are shown on sheet no. B-4.
- Logs of Explorations are shown on Sheet Nos. B-5 and B-6.

GRAPHIC SCALE



US Army Corps
of Engineers
Sacramento District

Rev.	Date	Design File no.	Spec No.	Drawing Code	File name	Plot date	Plot scale

Designed by	Drawn by	Reviewed by	Submitted by	Asst. Chief Soil Design Section
K. Pedernone	R. Jackson	K. Pedernone	K. Pedernone	

CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
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CALIFORNIA
AMERICAN RIVER PROJECT
LONG TERM STUDY

LOG OF EXPLORATIONS
4B-01-7(MB), 4B-01-8(MB) AND 4B-01-9(MB)

Sheet
reference
number:

B-6